Space Weather Technical Forecast

Issued on Thursday, 09 February 2023 at 01:16 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-flares (R1/R2 Radio Blackouts) likely. Active fluence expected Days 1 and 2 (9th and 10th).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with four M-flares observed. There are eight numbered and two unnumbered sunspot regions on the visible disc. The Peak flare was an impulsive M2.0 event at 08/0253 UTC from AR3213 near the north centre disc. This region is the largest and continues to slowly develop as it moves into the northwestern quadrant. It retains a beta-gamma-delta field, although the delta spot is rather small. A further large region is present in the north centre disc, AR3214, however this is a simple east-west aligned bipolar region and has remained stable. A newly numbered region, AR3217 has rotated over the southeastern limb and was responsible for an M1.5 flare at 08/2012 UTC. AR3212 rotated off the western limb, meanwhile two additional regions have also rotated over the eastern limb. No Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Solar winds are generally elevated with Earth in the fast wind from coronal holes 74 and 75. Observed speeds at L1 were generally 500-550 km/s, but increased to 560-600km/s around 08/0900 UTC. Since around 08/2000 UTC winds have begun to ease down to 520-570km/s. The density of the solar wind has been at or below average. Total IMF strength, Bt, was Weak to briefly Moderate, with a peak value of 11nT around 08/0730 UTC. The north-south component Bz, was variable, but more generally southward directed ranging -8nT to +8 nT. Phi angle was mainly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at Background levels throughout. The high energy electron flux (greater than 2MeV) measured by GOES-16 was at Background to Moderate levels initially, but increased to become predominantly High between 08/1245-2135 UTC, peaking 2520pfu at 08/1550 UTC, before returning to Moderate levels thereafter. The associated 24-hour electron fluence was below the Active level, but on a rising trend, with the observed fluence at 09/0000 UTC being 6.46e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with a slight chance of High levels being reached, mainly owing to the large sunspots in the northern hemisphere near centre disc, as well as further regions close to the eastern limb during the period.

Solar Wind / Geomagnetic Activity: CMEs which left the Sun on the 4th, 5th and 7th, while forecast to miss the Earth, give a low chance of glancing interactions between Days 1-4 (9th-12th). Otherwise, ongoing elevated solar winds due to the fast wind enhancement from CH74 and CH75 are forecast to gradually ease, with no other coronal hole sourced enhancements expected. Mainly Quiet to Unsettled geomagnetic activity is expected with a chance of isolated Active intervals. There is a very slight chance of G1/Minor storms.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is

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expected to remain at background levels, but with a slight chance of rising in response to any significant flares. High energy electron flux is currently Moderate to High. Similar conditions are expected on Day 1 (9th), with a gradual trend back to background levels likely by Day 3 (11th). The associated 24hr fluence is likely to continue to generally rise, now with the Active threshold (1e8 integrated pfu) expected to be reached on Day 1 and Day 2 (10th). In the absence of any significant geomagnetic activity, electron fluence levels should drop down below the Active threshold again between Days 2 and 3.

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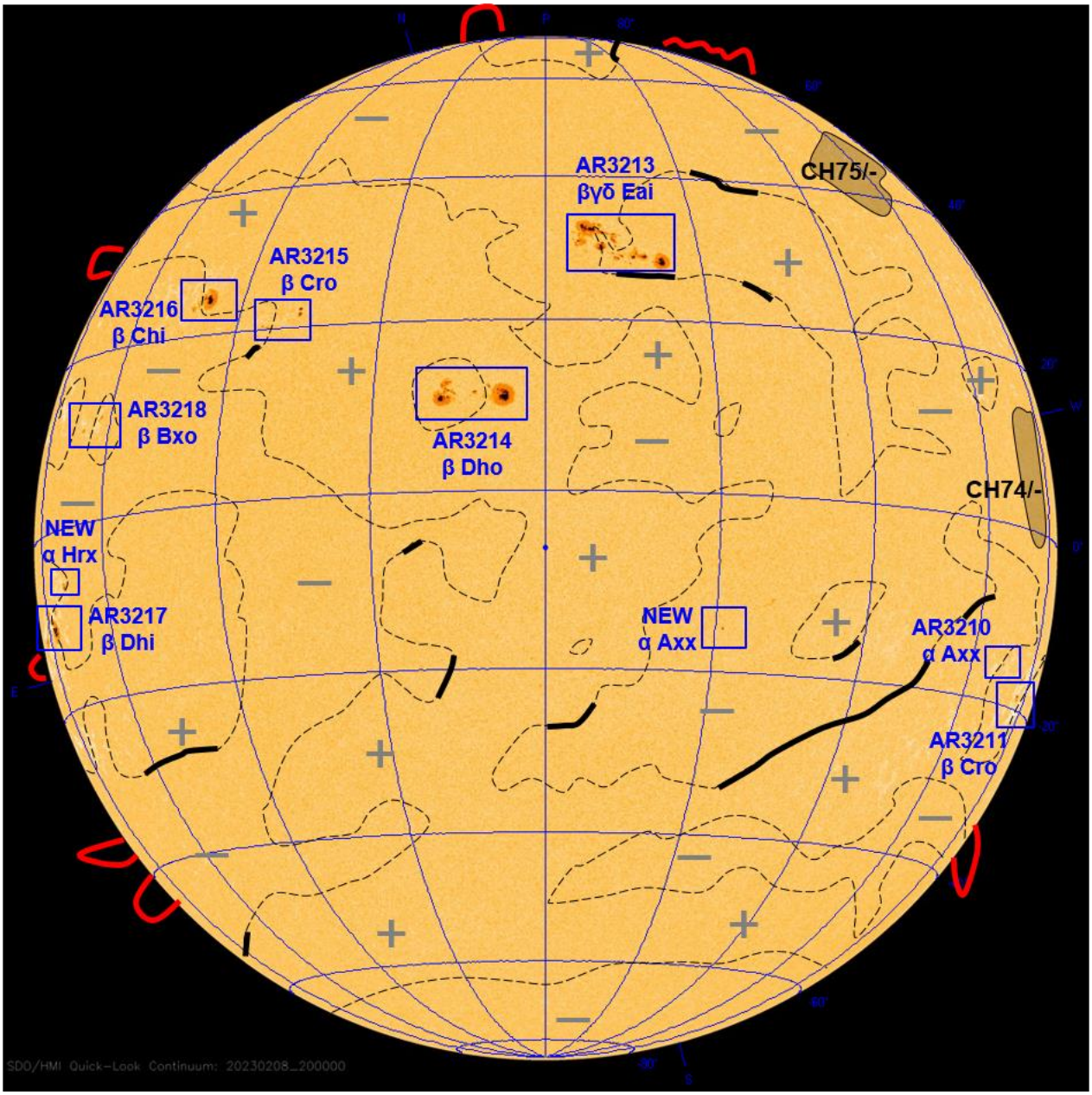
Figure 1. Solar Analysis Valid 08/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A number of CMEs are expected to miss, but pass close to Earth over the coming several days. These left the Sun on the 4th, 5th and 7th and given some uncertainty in their analysis, may give some peripheral interactions between Days 1-4 (9th-12th). Earth is currently experiencing the fast wind from one or both of coronal holes 74 and 75, but will gradually exit from this during the period, with no other new or recurrent features expected. Solar winds, though initially elevated, should exhibit a decline on Day 1 (9th), continuing into Day 2 (10th) towards a more background-like state by the end of Day 3 (11th) and probably remaining so into Day 4 (12th).

Mainly Quiet to Unsettled geomagnetic activity is expected, however given current fast winds and the low confidence CME outlook, Active intervals are possible on all days. There is a very slight chance of G1/Minor Storm intervals at any time during the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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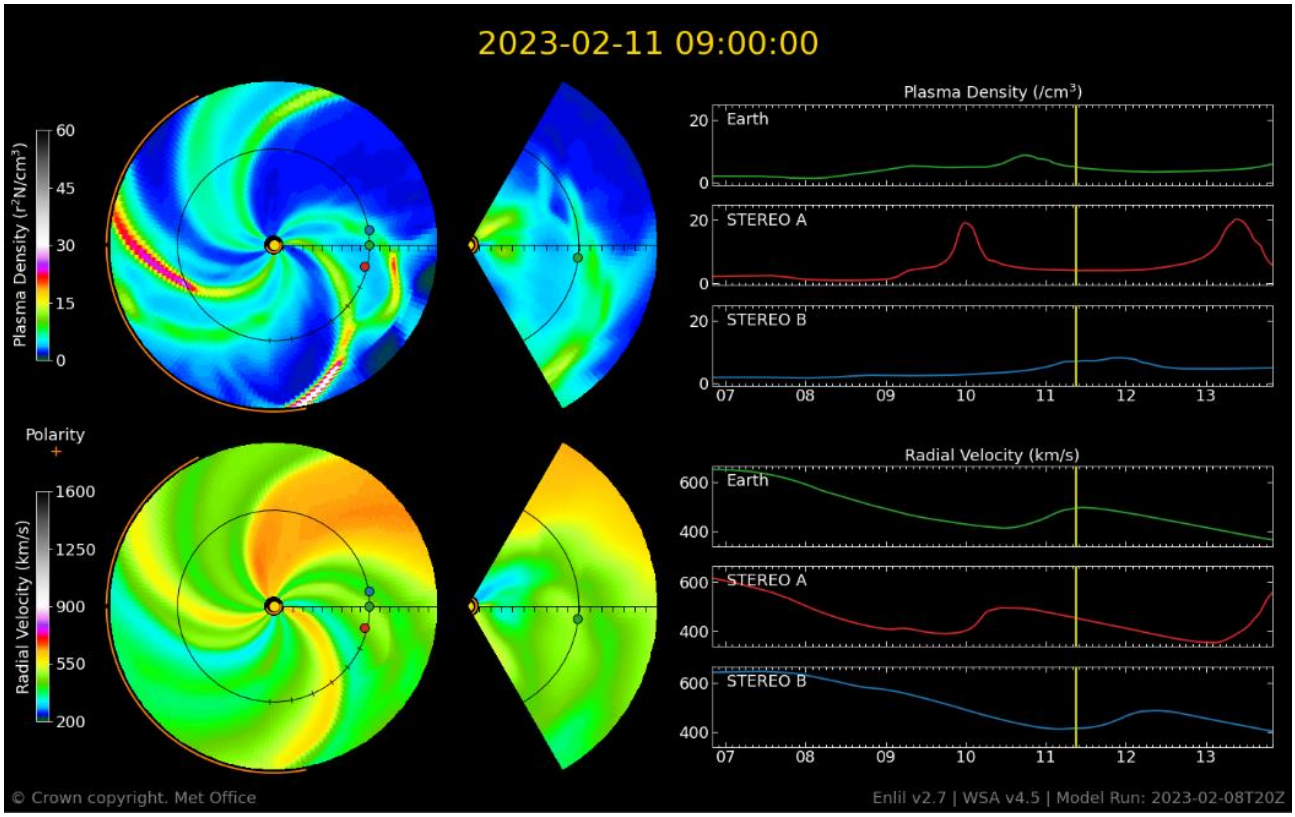
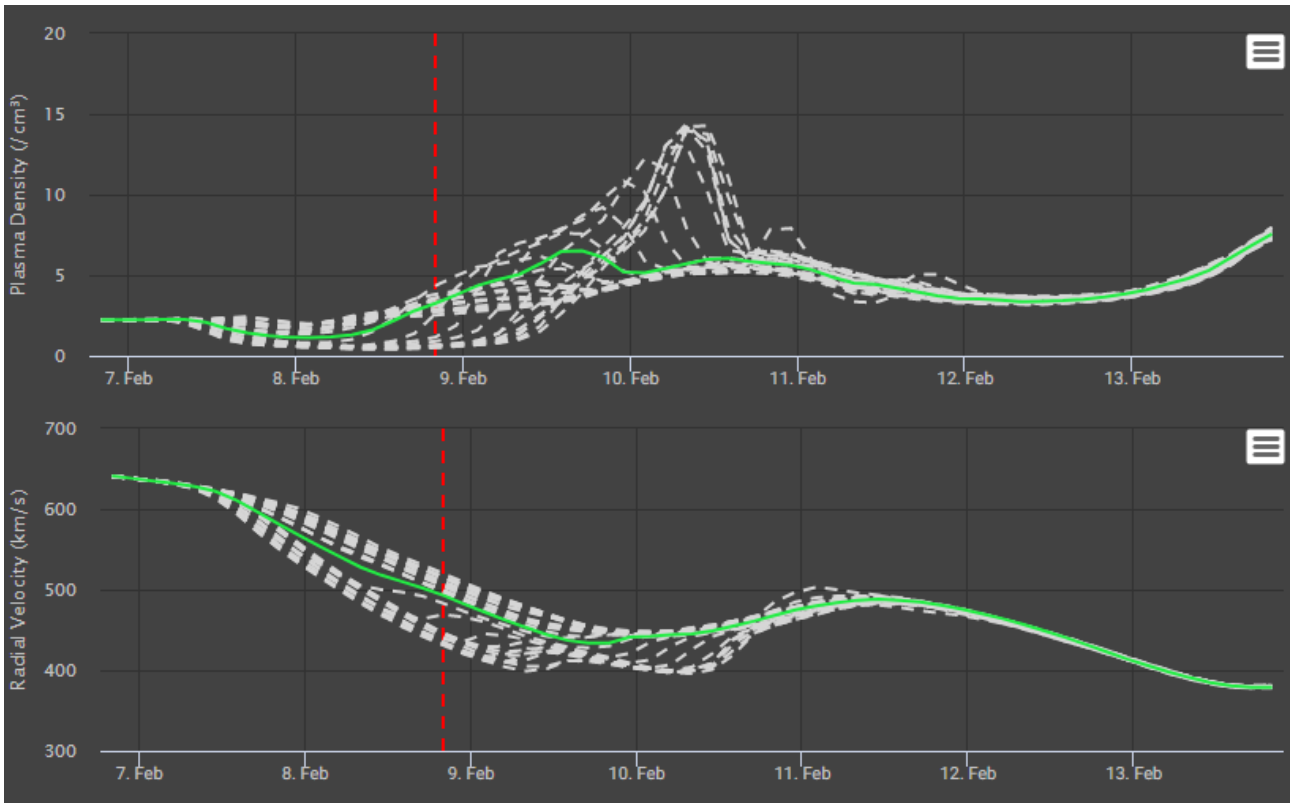
Figure 2: ENLIL showing CME passing above Earth on 11th Feb. Ensemble indicating uncertainty with various CME arrivals possible from 8-11th Feb.





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Radio Blackouts - X-Ray Flares:

Moderate activity is likely at times through the period, with a number of significant active regions on the disc. There are eight numbered regions and two unnumbered regions at present.

The most notable region is AR3213 in the northwest quadrant, which has been the source of a number of M-class flares in the past couple of days. This remains a relatively complex and moderately sized region. A single small delta region remains visible and the region also has some shear across its inverse polarity line. AR3214, is also a moderately sized region, but remains relatively simple in terms of its magnetic configuration. Of the new regions rotating on, newly numbered AR3217 appears to be the most developed, and associated with significant looping visible in SDO imagery. This region was responsible for an M1.5 flare at 08/2012 UTC. Further bright areas of flux are visible on STEREO-A imagery on the eastern limb, indicating the potential for additional areas to rotate onto the visible disc during the coming days.

Further M-flares are likely during the period, with a very slight chance of X-flares.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	60	50	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray flux

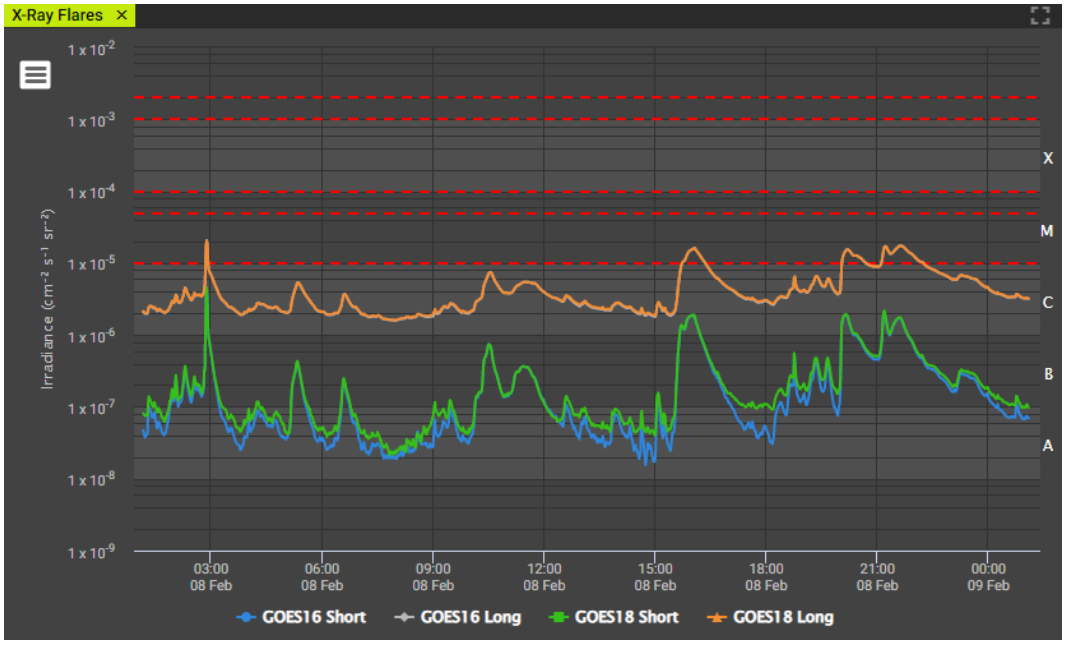

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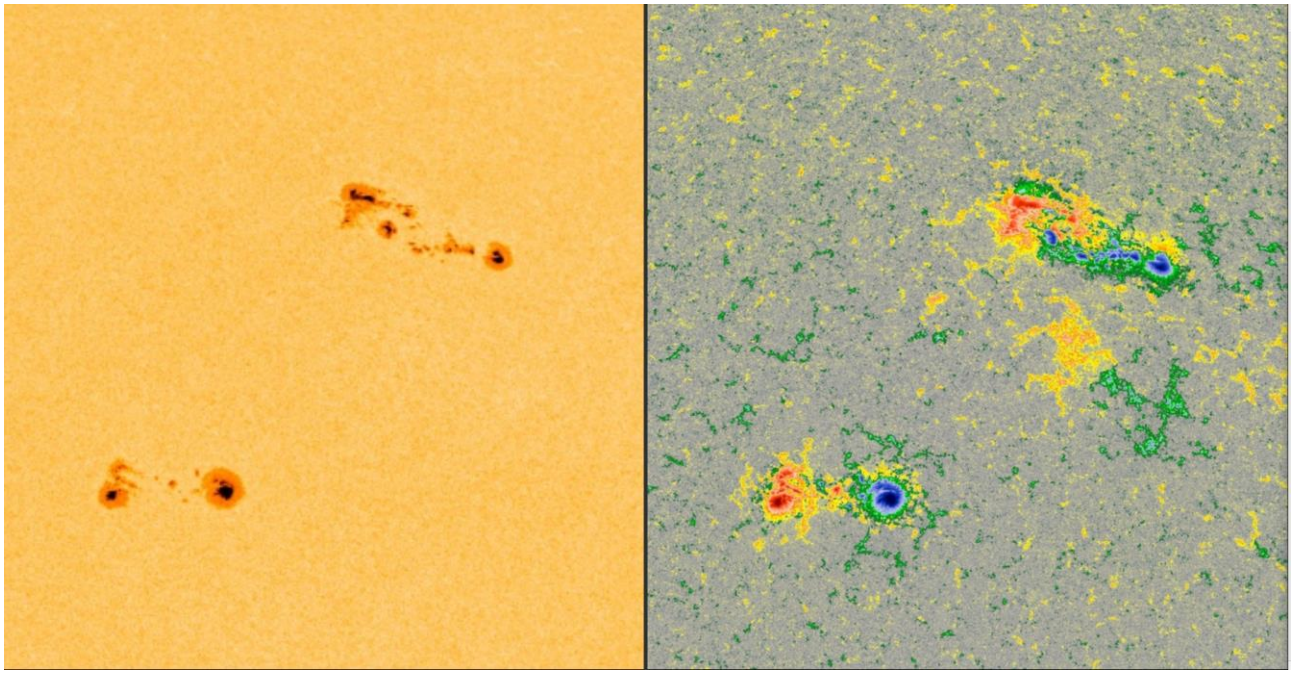
Figure 3b: SDO HMI Intensitygram and Magnetogram of two northern hemisphere, centre disc regions at 09/0030 UTC.



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Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux as observed by GOES16 is currently at background levels. No notable high energy proton response was observed from the M6.3 flare on 07/2307 UTC, however any further significant flares will give a slight chance of count rates increasing, with a very slight chance of reaching the S1 levels.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at Moderate to High levels as a result of the recent slight enhancement to the geospace environment from the arrival of the fast winds from CH74 and CH75. Similar conditions are expected on Day 1 (9th), with a gradual trend back to background levels likely by Day 3 (11th).

The associated 24hr fluence is likely to continue to generally rise, now with the Active threshold (1e8 integrated pfu) expected to be reached on Day 1 and Day 2 (10th). REFM forecast indicates the Active threshold will be reached later on Day 1, but with currently fluence values above this, it gives confidence for an earlier rise above the Active threshold. Beyond T+24 hours the model is less reliable due to its reliance on 27-day persistence which provides a poor comparison to recent conditions. However, in the absence of any significant geomagnetic activity, electron fluence levels should drop down below the Active threshold again between Days 2 and 3.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	80	80	30	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 4: >2MeV GOES-16 Electron Flux (above) and associated fluence (below) with REFM

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